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Content

Obsah

THE DESIGN AND PROFILE ANALYSIS OF THE EPITHESIS WITH THE INTEGRATED ELECTROSTIMULATOR

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Abstract: This thesis introduces the epithesis with the integrated electrostimulator as a rehabilitating and compensating aid which also has the aesthetic function. It presents the epithesis as an aesthetic replacement for people with the atrophy muscle of the lower extremities with missing muscular tissue. This work discusses different production processes, materials, possibilities variations epithesis shape and the realization of a prototype. It proposes the integration of the electro-stimulating unit into the epithesis which extends the possibilities of rehabilitation [1].
Key words: epithesis, atrophia, electrostimulator, polyurethane

1 INTRODUCTION

This work deals with a possible aesthetic solution to secondary problems of a paraplegic who suffers from cerebral palsy due to atrophy of muscles of lower limbs. The market offers the orthopaedic trousers for people confined to a wheelchair. These orthopaedic trousers are practical for wearing. For a woman, to feel good in clothes, it is necessary to ensure a good form and an appearance of the garment on the figure. The problem of fitting of a garment is its looseness because of the lack of muscle. The solution may be a profile that simulates the missing muscle. This would achieve a good fit of clothing. This profile can be called epithesis. Epithesis is replacement of lost body parts for cosmetic reasons. Integrated electrostimulator is suggested for extending of the functionality of epithesis, which enables the rehabilitation of sagging muscles [1].

2 THE DESIGN OF THE EPITHESIS

The proposed compensation and rehabilitation aid should cover the affected leg from a hip to an ankle. It should be well - shaped, breathable and with a smooth surface. Material used for epitesis should be lightweight, flexible and very strong too, so that is could simulate the missing muscle most suitably. Selected epithesis consists of cloth cover and the core of the material simulating muscle tissue. Epithesis is a cosmetic replacement of body parts without the compensation of the lost function.

2.1 The core of the epithesis

The core of epithesis is based on the anatomy of the lower extremities. The resulting shape should be obtained from the difference between a normal profile and profile legs of atrophied limbs. The core of epithesis can serve as a way for the integration of electrostimulation unit for rehabilitation of muscles.

2.1.1 Design shape of the core

The design of the form was based on the anatomy of the lower extremities in the seated position (the position of sitting in a wheelchair). To create a shape of epithesis on an individual figure, it is necessary to take the people specific body measurements. You can see in Figure 1 some of body measurements

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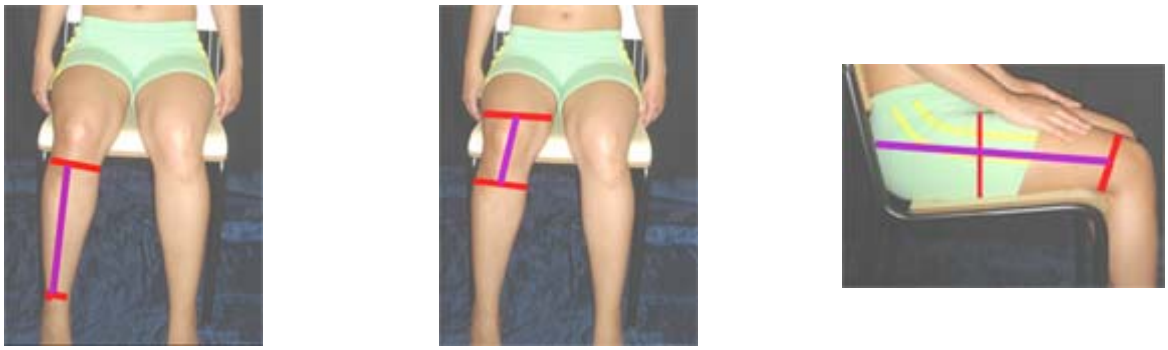

Figure 1 These body measurements [1]

The prototype design of the epithesis shape was created in AutoCAD based on individual dimensions of the people. It consists of three parts, the thigh, knee and calf parts Figure 2.

Figure 2 The design in AutoCad [1]

2.1.2 Typing material of the core of the epithesis

Different types of foams appear as the most suitable materials. For example: polyurethane, silicone, natural latex or synthetic latex foam.

Factors affecting the selection are as follows:

- good formability,
- both relative softness and strength,
- permeability (comfort),
- bacteriostatic and bactericidal properties,
- the price availability of the material.

2.2 The cover of the epithesis

2.2.1 The pattern of the epithesis cover

The form of the epithesis cover is based on the design of the profile of the epithesis core. Patterns can be obtained either by direct construction based on the input body measurements or developing the surface of the core obtained in the 3D software.

2.2.2 Typing material of the epitheses cover

CoolMax® material was chosen for its excellent properties. It preserves a human body permanently dry and warm. It has an excellent ability to drain humidity away. It keeps continuous layer of air on a body which is heat-stable in both cold and warm environments. It is not prone to take bad odours. There is easy maintenance of material.

3 PROTOTYPING

Some projects of foreign students University of Minho preceded the development of prototype. The prototype was designed on the basis of their experience - both good and bad [2]. Four stages of development were before the final prototype.

3.1 Profile Cutting

The polyurethane foam was chosen for the prototype. It can be easily cut by resistance wire and other tools (such as scissors, knives, boxes cutters, etc.). Polyurethane foams are offered in different kinds of strength and water vapor. Resistance cutter was used for cutting epithesis core - option 1 Figure 3.

Figure 3 The core of the epithesis - option 1 [1]

3.2 Making cloth cover

The cover must meet several functions simultaneously. This is primarily a function of so-called "smart" materials. This material drains away excess fluid from the skin surface thanks to better-shaped fibers. Practical function includes: the appropriate forms of fastening, the possibility of easy maintenance of package, removing the cover because of washing. Aesthetic function helps to complete an epithesis appearance. Correct construction style is important for perfect fit of the cloth cover and the epithesis core. These patterns needed to manufacture cloth cover were created in AutoCAD Figure 4.

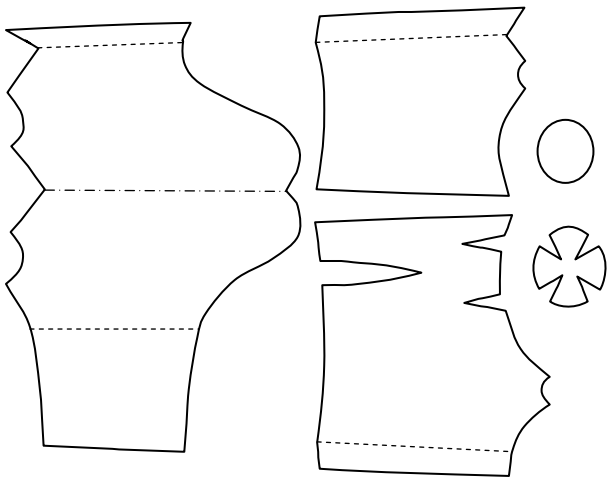

Figure 4 Patterns of cloth cover [1]

We will fix complete epithesis with the help of harness on lower extremities see Figure 5.

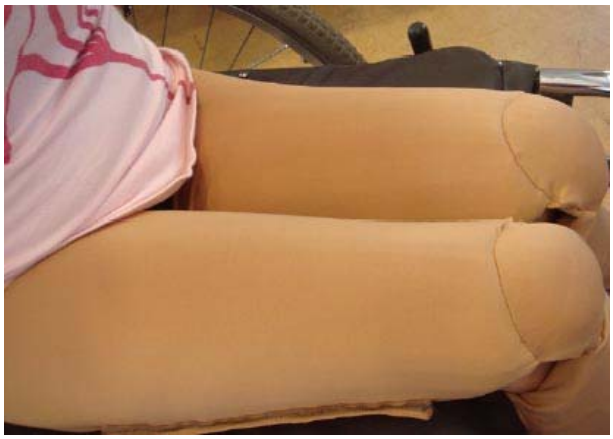

Figure 5 Complete epithesis – option 1 [1]

3.3 Modification of functional properties of epithesis core

The goal is to increase the physiological comfort of epithesis (Design option 2). Creation of longitudinal grooves in the "V" shape increased airflow and thus increased the physiological comfort. You can see in Fig.6. These grooves allowed to shape epithesis into an appropriately shaped curve. After the application it copies the profile shape of the limb. Difficult epithesis shaping profile was resolved by this adjustment. The second modification increased the permeability of polyurethane. These openings were created on the whole surface epithesis. You can see in Fig.6.

3.4 Integration electrostimulator

Device XFT-320 with two outputs was selected for incorporation electrostimulation unit into the profile. Each for one extremities. The outputs are terminated with two interchangeable gel electrodes. These gel "pads" have an adhesive surface and therefore it is easy to put them there instead of stimulation. These holes in the epithesis core were used to integrate the outputs from electrostimulator see Figure 6.

Figure 6 Profile with grooves and openings - option 2 and profile with gel electrodes [1]

4 CONCLUSION

The main subject of this work was to propose epithesis for people with lower limb muscle atrophy. The profile which is responsible for simulating a missing muscle was designed in AutoCAD.
Several possible materials were collected to create the epithesis, both for the manufacturing cores, and for creating packages. Expanded polypropylene is thought of best for the core. It is a material with good formability, good physiological properties, lightweight material and with good bacteriostatic and bactericidal properties. Several modifications have been created to improve the physiological epithesis comfort and fit on the atrophied limb. Perforation of the core offers several ways of the integration of the electrostimulation profile. Epithesis can also be used as a rehabilitative aid.

5 REFERENCES

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NÁVRH A ANALÝZA PROFILU EPITÉZY S INTEGROVANÝM ELEKTROSTIMULÁTOREM

Translation of abstract:
The design and profile analysis of the epithesis with the integrated electrostimulator

Tento článek představuje návrh epitézy s integrovaným electrostimulátorem. Epitéza je navržena jako rehabilitační a kompenzační pomůcka, která má také estetickou funkci. Epitéza je navržena jako estetická náhrada pro osoby s atrofií svalů dolních končetin s chybějící svalovou tkání. Tato práce se zabývá výrobním postupem a vytipováním vhodného materiálů na výrobu epitézy. V neposlední řadě řeší možnosti změny tvaru epitézy vzhledem k její funkčnosti a fyziologickým vlastnostem. Výsledkem práce je realizace prototypu.
Pro rozšíření funkčnosti epitézy je navržena integrace elektro-stimulační jednotky, což umožňuje využití epitézy zároveň jako rehabilitační pomůcky.

THE SORPTION ABILITY OF TEXTILE FIBRES

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Abstract: *Sorption capacity of textiles fibres for surfactants and water is discussed. Adsorption of surfactants is characterized through adsorption isotherms, adsorbed, desorbed and residual amount of ionic surfactants in variation of hydrophilic and hydrophobic part and concentration as well. Water sorption is expressed as moisture content and water retention value of textile fibres. Cationic and anionic surfactants are adsorbed on the cotton, wool, polyester and polypropylene fibres at 20°C for 60 minutes. Desorption of surfactants is performed at 20°C for 30 minutes. The results obtained indicate that the key parameters in adsorption process are concentration and composition of the surfactants, as well as the swelling capacity of textile fibres.*
Key words: *surfactants, adsorption, isotherms, desorption, micelles, fibres*

1 INTRODUCTION

The adsorption of surfactants at solid-liquid interface is influenced by a number of factors [1]: the nature of the structural groups on the solid surface (adsorbent); the molecular structure of the surfactant (adsorbate) and the environment of the aqueous phase. Therefore, the above mentioned factors indicate that possible interactions between adsorbent and adsorbate in the aqueous phase are complex [2-5]. An alternative to adsorption for additional surfactant molecules existing in solution is to build aggregates of colloidal dimensions named micelles. The spontaneous formation of micelles is clearly evident from the changes of physico-chemical properties of the surfactant solution, mostly characterized by narrow concentration range, known as critical micelle concentration (CMC). Micelles are not surface active; the significance of CMC is the equilibrium concentration, where surface chemistry ends and colloid chemistry begins. Micellisation and adsorption are two processes; in general the adsorption process is active at lower concentrations than micellisation, so when more of surfactant is added, it usually takes place first [6].

The electric double layer can be created when textile fibres are in contact with an aqueous solution, due to dissociation of suitable molecular groups or the preferential adsorption of one sort of ions or both [7, 8]. The electrical properties of solid surfaces depend on the pH of the aqueous solution. Most textile fibres have functional dissociable group or groups present at the surface. The complete dissociation of functional groups deals with maximum value of zeta potential (ξ_{max}) presented by the plateau of zeta potential in the function of pH [9]. The important and characteristic value of solid surface is an isoelectric point (IEP), labelled as the pH, at which zeta potential is zero. Possible interactions between fibre surface charge and dominant solution particles are important for monitoring or highlighting the adsorption mechanism [10]. A type of adsorption isotherm indicates adsorption mechanism depending upon the surfactant nature and concentration, as well as upon the composition and structure of textile fibres.

The paper deals with sorption ability of textile fibres, characterised by moisture regain, water retention value (WRV), surface charge, as well as by the adsorbed, desorbed and residual amount of ionic surfactants.

Adsorption of ionic surfactant in the concentration range (below and above of CMC) was studied in variation of hydrophilic and hydrophobic part.

2 EXPERIMENTAL

2.1 Adsorbent

Fibres were selected among different types of natural and synthetic ones. The characteristics of commercially available textile fibres, including processing parameters, were as follows:

-COTTON fibres (CO) of an average length of 29 mm, Maturity from 70 to 80 %, Micronaire from 3.8 to 4.2 and Pressley from 87000 to 90000; were pre-bleached with hydrogen peroxide;

-WOOL fibres (WO) of Australian origin with length 73.9 mm and fineness 22.3 μm; were washed in commercial conditions;

- Polyester (PES) fibres with linear density of 3.17 dtex
- Polypropylene (PP) fibres with linear density of 3.3 dtex.

2.2 Adsorbate

The ionic surfactants of analytical grade were purchased from Sigma-Aldrich. The choice of cationic surfactants was based on the variation of hydrophilic group: quat and pyridinium group. Additionally, alkyl chain, from C12 to C16 was varied only in the case of quat group, while pyridinium group was attached to the C 16 alkyl chain. The series of cationic surfactants included:

- Dodecyl trimethyl ammonium bromide **(DDTMAB)**
- Hexadecyl trimethyl ammonium bromide **(HDTMAB)**
- Hexadecyl pyridinium chloride **(HDPC)**

Various hydrophilic groups were included in the series of anionic surfactants: sulphate and sulphonate; sulphate attached to the C 12 alkyl chain and sulphonate to C12 alkyl aryl chain. The series of anionic surfactants included:

- Sodium dodecyl sulphate **(SDS)**
- Sodium dodecylbenzene sulphonate **(SDBS)**

2.3 Adsorption isotherms, adsorption and desorption

Adsorption isotherms of tested ionic surfactants were designed selecting different concentrations: below, near and above CMC (Table 1).

Ionic surfactants of different concentrations (Table 1) were adsorbed on the 5 g of textile fibres at pH 7 in the bath ratio of 1:20 at 20°C for 60 minutes. The process was performed in the Linitest apparatus, Original, Hanau until equilibrium was reached.

Textile fibres were separated afterwards and centrifuged for 60 seconds at 1420 rpm. Drying followed at 40°C for 60 minutes.

After the adsorption (A) of surfactant from the solutions in the concentrations (c_2 and c_4 from Table 1), desorption (D) of surfactants from dried fibres was carried out in distilled water, also in Linitest apparatus at 20°C in the bath ratio of 1:40 for 30 minutes.

Table 1 CMC of tested anionic and cationic surfactants and selection of applied concentrations for adsorption isotherms

SURFACTANTS					
CATIONIC	**CMC [mmol/L]**	**c_1 [mmol/l]**	**c_2 [mmol/l]**	**c_3 [mmol/l]**	**c_4 [mmol/l]**
DDTMAB	14	4.8648	9.7295	14.5943	19.4590
HDTMAB	0.91-1.6	0.2744	0.6860	1.3719	2.0579
HDPC	1.24	0.4190	0.8380	1.2570	1.6760
ANIONIC	**CMC [mmol/L]**	**c_1 [mmol/l]**	**c_2 [mmol/l]**	**c_3 [mmol/l]**	**c_4 [mmol/l]**
SDS	8.6	2.9475	5.8950	8.8425	11.7900
SDBS	1.1	0.3444	0.861	1.0331	1.722

2.4 Methods

Potentiometric titration method was applied for the determination of surfactants using automatic titrating instrument Titrino 736 GP (Metrohm, Swiss). The commercial ion selective electrode, ISE 6.0507.150, was used as appropriate for anionic and cationic surfactants with adequate variation of pH. Sigma-Aldrich products were applied as titrants, benzethonium chloride (Hyamine 1622) for anionic and sodium dodecyl sulphate (SDS) for cationic, both in the concentration of 4 mmol/l.

Streaming current method was applied to measure electrokinetic potential of textile fibres using Electrokinetic Analyzer (EKA) designed by Anton Paar GmbH, Graz, Austria. Cylindrical cell was used as the most appropriate for fibrous material. Prior to measuring zeta potential, textile fibres were purified in an organic solvent following the procedure according DIN 54278. The fibres were rinsed in deionized water afterwards, until conductivity lower than 4 x 10^2 μS/m was reached. The electrolyte solution (1 mmol/l KCl) was forced through the cell. Streaming potential was measured versus pressure by means of Ag/AgCl electrode in dependence of pH. Zeta potential was calculated according to the Smoluchowski equation [11].

Water retention value (WRV) was chosen as an appropriate and certain parameter for the determination of fibre swelling capacity. The method according to DIN 53814 is based on the fibres swelling capacity as well as the ability of water retention under controlled conditions (2 g of fibres were soaked during 2 hours and centrifuged during 5 and 20 minutes).

Moisture regain of cotton, wool, PES and PP fibres was determined according to ASTM D 2654 89a. Textile fibres were exposed to standard atmosphere following the standard DIN 53802.

3 RESULTS AND DISCUSSION

Sorption properties of selected adsorbents are characterized by water retention value (WRV) and moisture regain (% H_2O), Table 2.

Table 2 Moisture regain and WRV of selected textile fibres

Fibres	% H_2O	WRV/5	WRV/20
CO	8.34	39.6	35.3
WO	11.91	36.5	34.0
PES	0.93	0.9	0.3
PP	0	0	0

There is a significant difference between natural and synthetic fibres, indicating that the composition of textile fibres causes variation in sorption ability. Higher values of water sorption and retention in the case of natural fibres are influenced by accessible reactive groups. The sorption capacity of PES fibres is low. No water uptake of PP fibres is influenced by hydrophobic nature.

Electrokinetic properties of the adsorbent are evaluated by zeta potential, as an important parameter for surface characterisation, especially in wet processing of textiles, Figure 1.

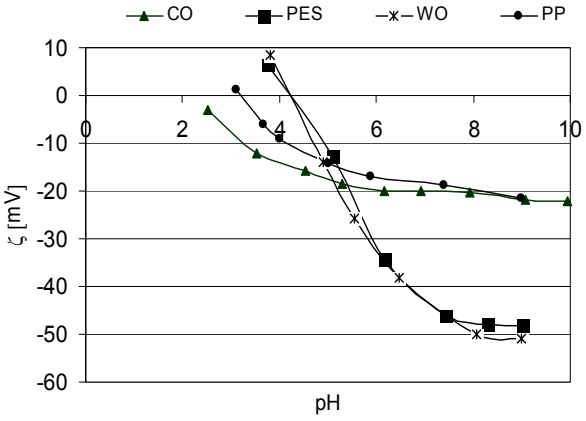

Figure 1 Zeta potential of cotton, PES, wool and PP fibres in dependence of pH 1 mmol/l KCl

Cotton fibres are negatively charged in an alkaline and neutral aqueous solution, mainly due to the presence of hydroxylic or carboxylic groups. Previous results showed that the stage of pre-treatment process significantly affected swelling properties, the accessibility of reactive groups and surface charge [12]. It is confirmed by titration with

an acid (0.1 mol/l HCl) and back titration with a cationic surfactant (0.002 mol/l HDPC).
Amphoteric properties of wool fibres are the result of the amino (-NH_2) and carboxylic (-COOH) groups. The dissociation of wool fibres in aqueous solutions depends on pH; Wool fibres are positively charged in an acid medium (pH < IEP), because of the dissociation of –NH_2 groups. Negative charge of the wool fibres in neutral and an alkaline medium (pH > IEP) results from the dissociation of –COOH groups. Wool fibres have a high value of zeta potential in alkaline and neutral aqueous solutions, compared to cotton fibres.
Most hydrophobic synthetic fibres, including PES fibres, have a highly negative value of zeta potential (according to Jacobasch from -40 to -80 mV) [7]. Esterified carboxylic groups of PES fibres result in strongly negative zeta potential values. Polypropylene fibres have a considerably lower negative zeta potential than the polyester ones, due to specific structure, very low sorption ability, presence of non-polar CH_2 groups in the chain and CH_3 groups at the end of the chain. Adsorption of the surfactants, dyes, polyelectrolytes, etc. which all have the opposite charge to the adsorbent, adsorption may take place in Stern layer and extend into the surface layer of swollen fibres. Specific hydrophobic-hydrophilic or polar-nonpolar nature of surfactant molecule enables their wide application in textile finishing. They change electrokinetic properties of the adsorbent. The magnitude depends on the distribution and length of hydrophobic part, as well as on the charge and position of hydrophilic group in the surfactant molecule [4]. Adsorption isotherms of cationic surfactant, DDTMAB on cotton, wool, PES and PP fibres are presented in Figure 2.

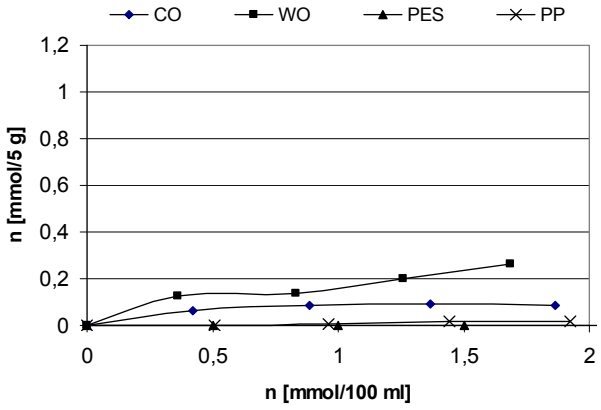

Figure 2 Adsorption isotherms of **DDTMAB** on cotton (CO), wool (WO), PES and PP fibres

Critical micelle concentration (CMC) of DDTMAB is rather high, due to a shorter hydrophobic chain (C12), Figure 2. The lowest concentration applied (1.5 g/l) is below CMC, and at the same time the only one technologically acceptable. It is obvious that synthetic fibres, PES and PP, exhibit rather poor adsorption of this cationic surfactant, despite the negative surface charge. Hydrophobic properties prevail in adsorption, together with low swelling ability of the fibres (Table 3). Wool fibres absorb somewhat higher amount than cotton, which is especially noticeable in the area above CMC. Complex wool fibres, with good swelling ability, have partially broken the micelles, which results in lower concentration than CMC in the solution.
The amount of adsorbed (A), desorbed (D) and residual (R) amount of cationic surfactant, DDTMAB, in dependence of textile fibres composition is presented in Figure 3

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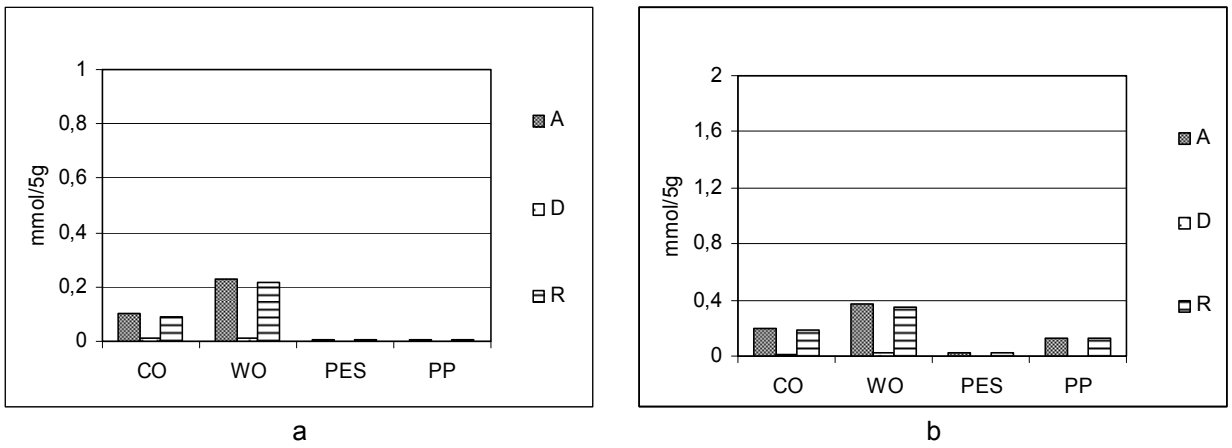

Figure 3 Adsorbed (A), desorbed (D) and residual amount (R) of **DDTMAB**
selection of concentration for adsorption a: c_1=0.9729 mmol/100 ml; b: c_2=1.9459 mmol/100 ml

The amount of adsorbed DDTMAB on natural fibres of relevant sorption capacity is low despite of the opposite charges (surfactant and fibres surface), Table 3, Figures 1 and 3. Low amount of adsorbed DDTMAB is mostly retained during desorption in rinsing process.

Adsorption isotherms of the surfactant HDTMAB, Figure 4, are of different shape and slope compared to DDTMAB.

Its adsorption on the PES and PP fibres is somewhat higher. The CMC of HDTMAB is lower than CMC of DDTMAB, as the length of the hydrophobic chain has an impact on CMC.

The amount of adsorbed HDTMAB on cotton fibres is higher than on the wool ones. It proves that electrokinetic potential is not dominant in the adsorption of HDTMAB. The surfactant applied in the concentrations below CMC is fully adsorbed. Cotton and wool fibres intensively adsorb selected surfactant concentrations in the regions near to and above CMC.

The amount of adsorbed and desorbed HDTMAB shows strong sorption and retention ability of natural fibres, as compared to synthetic ones. The lengthening of the alkyl chain in the hydrophobic part of HDTMAB results in lower CMC and adsorption increases in comparison to DDTMAB, Figure 5.

The introduction of the pyridine ring in the hydrophilic part of the surfactant molecule HDPC impacts CMC, Figure 6. The shape and slope of the HDPC adsorption isotherm is similar to the HDTMAB isotherm for all the fibres tested.

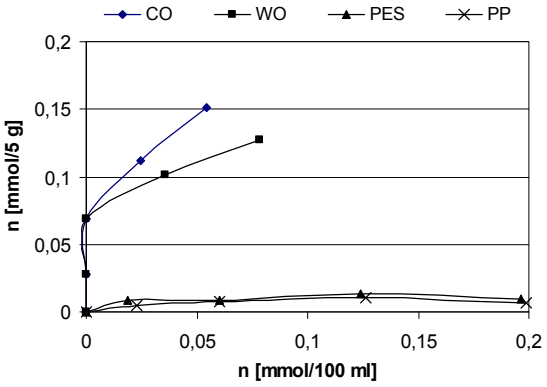

Figure 4 Adsorption isotherms of **HDTMAB** on cotton (CO), wool (WO), PES and PP fibres

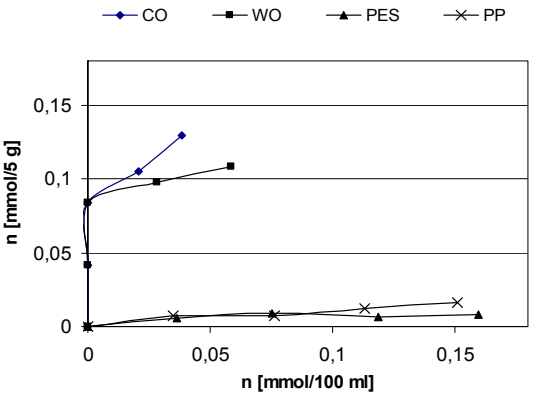

Figure 6 Adsorption isotherms of **HDPC** on cotton (CO), wool (WO), PES and PP fibres

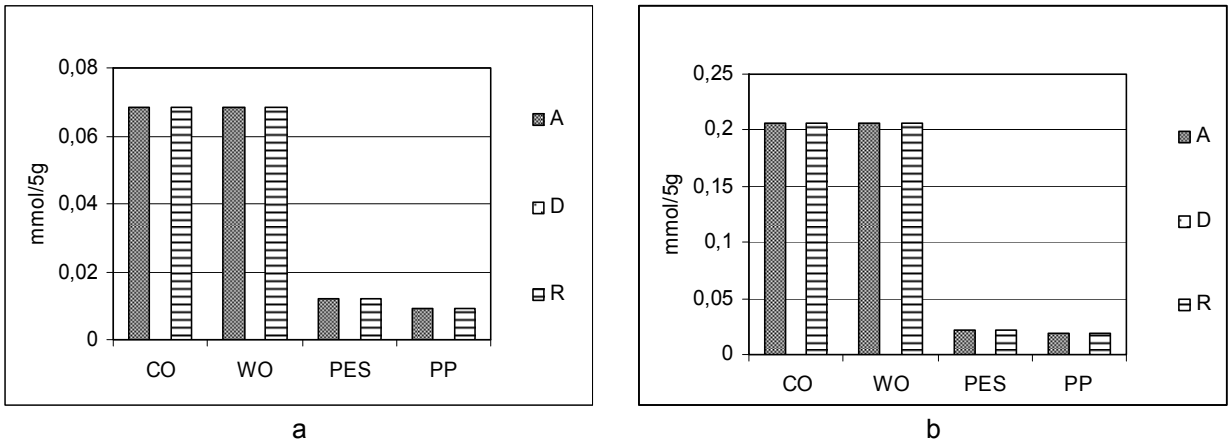

Figure 5 Adsorbed (A), desorbed (D) and residual amount (R) of **HDTMAB**
selection of concentration for adsorption a: c_1=0.0686 mmol/100 ml; b: c_2=0.2057mmol/100 ml

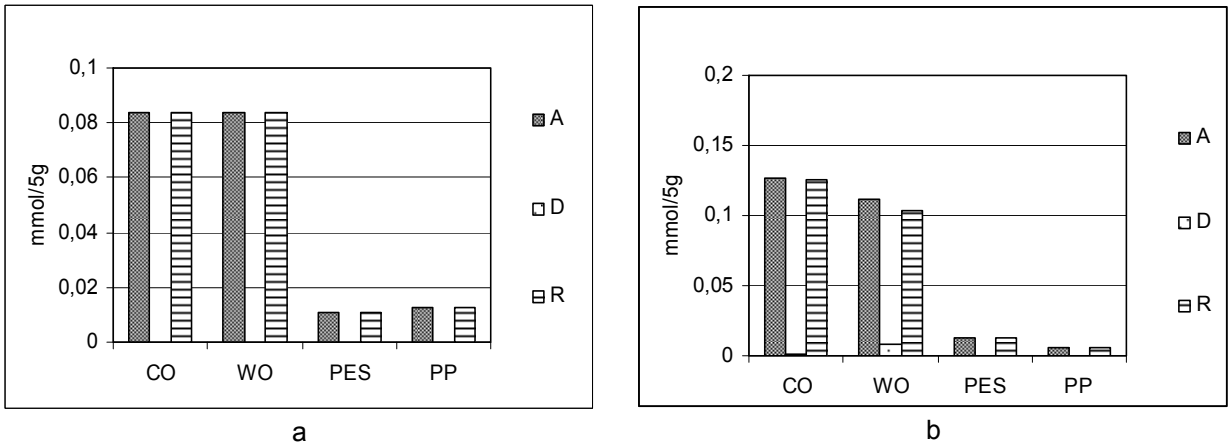

Figure 7 Adsorbed (A), desorbed (D) and residual amount (R) of **HDPC**
selection of concentration for adsorption a: c_1=0.0838 mmol/100 ml; b: c_2=0.1676 mmol/100 ml

The type of adsorption isotherms indicates the importance of surfactant composition, as well as the equilibrium of the hydrophilic and hydrophobic parts of the surfactant for its adsorption to particular textile fibre, Figure 7. Weaker adsorption of HDPC applied above CMC is primarily the result of more prominent steric barrier. Possible additional reason can be lower CMC of HDPC in comparison to HDTMAB.

The adsorption of anionic surfactants is possible if the potential barrier of the negatively charged fibre surface has been overcome. The tendency is decreased by electrostatic repulsive interactions, Figures 8 - 11.

The adsorption potential of textile fibres for SDS is generally poor. Cotton fibres also exhibit poor adsorption of this surfactant, regardless of the concentration range, below and above CMC alike, Figure 8. Among the fibres tested, wool exhibits the best adsorption properties, regardless of the concentration range applied, both below and above CMC, Figure 8.

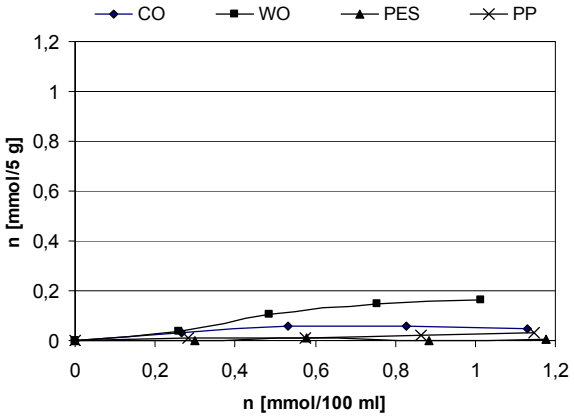

Figure 8 Adsorption isotherms of **SDS** on cotton (CO), wool (WO), PES and PP fibres

Desorption of SDS, from cotton and wool fibres during rinsing, is low. The adsorbed and desorbed amounts are mostly the result of sorption power expressed through WRV, Figure 9.
The surfactant SDBS is a constituent of the washing agent used. The presence of benzene ring in the hydrophobic part results in lower CMC, compared to SDS, Figure 10. This contributes to higher adsorption than is the case with SDS. Higher adsorption of this surfactant is also recorded on synthetic fibres. Cotton and wool fibres completely adsorb SDS at the lowest concentration (0.15 g/l). Wool and cotton fibres adsorb the surfactant at higher concentration as well, with the adsorption coefficient dropping to below 50 %. Adsorption and low desorption of SDBS from cotton and wool fibres are the result of fibre sorption and retention ability. The adsorption of SDBS on the synthetic fibres results from hydrophobic and steric interactions mostly dominant due to the presence of benzene ring in the hydrophobic part, Figure 11.

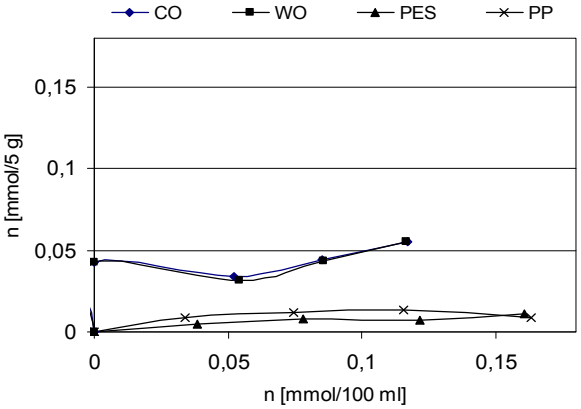

Figure 10 Adsorption isotherms of **SDBS** on cotton (CO), wool (WO), PES and PP fibres

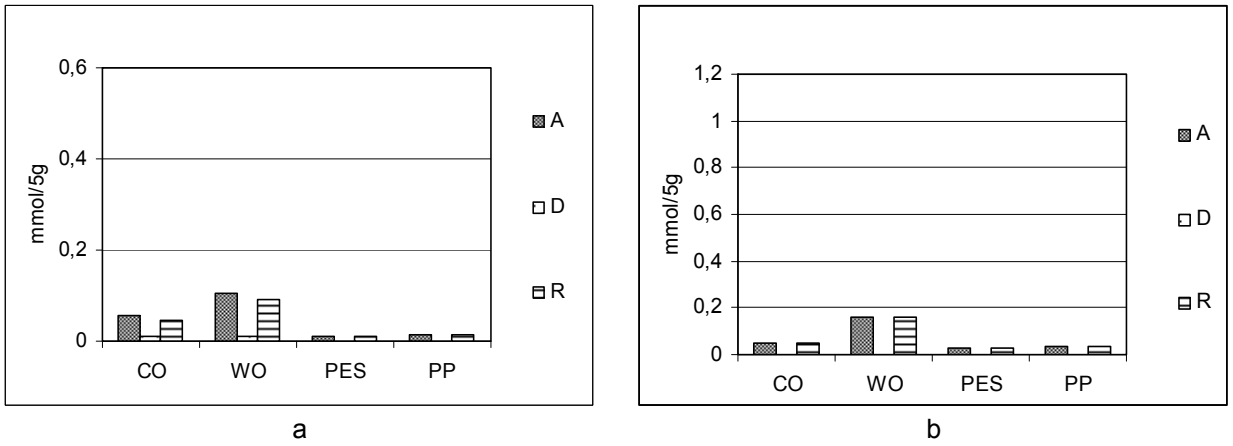

Figure 9 Adsorbed (A), desorbed (D) and residual amount (R) of **SDS**
selection of concentration for adsorption a: c_1=0.5895 mmol/100 ml; b: c_2=1.179 mmol/100 ml

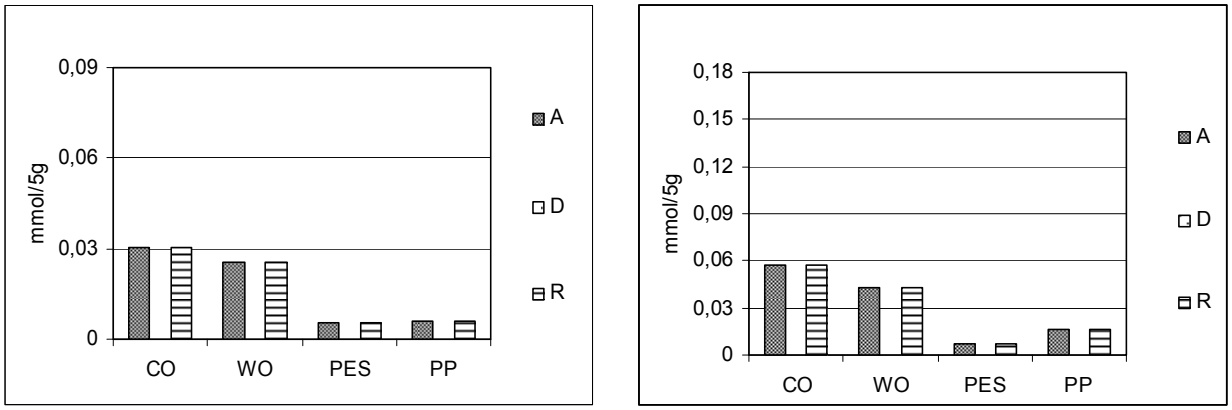

Figure 11 Adsorbed (A), desorbed (D) and residual amount (R) of **SDBS**
selection of concentration for adsorption a: c_1=0.0861 mmol/100 ml; b: c_2=0.1722 mmol/100 ml

4 CONCLUSIONS

The adsorption isotherms of anionic and cationic surfactants on cotton, wool, PES and PP fibres are interesting and complex. Adsorbent and adsorbate properties like: hydrophilic-hydrophobic ratio in a surfactant molecule, its solubility and dissociation, as well as fibre structure and active groups and their properties respectively are the most prominent ones.
Results obtained indicate that the key parameters in adsorption process are the concentration and composition of the surfactants, as well as the composition of textile fibres. The influence of zeta potential is essential in the study of selected surfactants. The results show a significant impact of fibre swelling and retention capacity on the adsorbed and desorbed amount of ionic surfactants.

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SORPČNÁ SCHOPNOSŤ TEXTILNÝCH VLÁKIEN

The translation of article
The sorption ability of textile fibres

V príspevku sa skúma sorpčná kapacita textilných vlákien vzhľadom na povrchovo aktívne činidlá (detergenty) a vodu. Adsorpcia detergentu je charakterizovaná adsorpčnými izotermami, adsorbovaným, desorbovaným a zvyškovým obsahom iónového detergentu pri striedaní hydrofilnej a hydrofóbnej časti a tiež koncentráciou. Sorpcia vody je vyjadrená ako obsah vlhkosti a zádrž vody v textilných vláknach. Katiónový a aniónový detergent sa absorboval na bavlnené, vlnené, polyesterové a polypropylénové vlákna 60 min pri 20°C. Desorpcia sa uskutočnila 30 min pri 20°C. Získané výsledky ukazujú, že rozhodujúce parametre pri adsorpčných procesoch sú koncentrácia a zloženie detergentov a tiež kapacita napúčania textilných vlákien.

HYDROPHILIC PROPERTIES OF POLYPROPYLENE NONWOVENS AFTER POLYELECTROLYTE LAYERS DEPOSITION

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Abstract: *The study examines the hydrophilic properties of a polypropylene nonwovens modified using layer-by-layer method. Poly(acrylic acid) and poly(allylamine hydrochloride) were applied in order to prepare various types of multilayers. It was found that that moisture sorption, capillacity, wettability and water uptake increase substantially after polyelectrolyte deposition.*
Key words: *polypropylene nonwoven, layer-by-layer method, polyelectrolytes, hydrophilic properties*

1 INTRODUCTION

The preparation of thin, mainly organic layers containing functional groups, designed for modifying the surface properties of flat objects, is now the subject of a wide interest.
The main principle of the layer-by-layer (lbl) method consists in alternately depositing oppositely charged polyelectrolyte layers, which react between themselves owing to electrostatic forces. Using this kind of modification it is possible to obtain products that combine the properties of the main object with the superficial parameters of a new external layer. Through an appropriate selection of the layer to be deposited one can very precisely control the surface properties of the given product adjusting them to concrete requirements and needs.
Our previous papers described the use of the lbl method for the modification of polypropylene and polyester fibres [1-5]. It has been shown that this method can be also used for textile fabrics.
Textile goods during their use are often subjected to the action of water. The parameters of hydrophilicity or hydrophobicity of textiles depend on the purpose they are designed for. The absorption of water by textiles can proceed as a result of [6]:

- water penetration into the inside part of fibres until their maximum hygroscopic saturation;
- wetting the surface of textile goods and the component fibres;
- wetting the capillaries and slots formed by fibres and threads (capillarity);
- pressing water into free fabric spaces under pressure.

Fabrics subjected to the action of water contain most frequently some moisture derived from their surroundings. Their contact with water brings about outer wetting as well as an increase in their moisture content until the maximum hygroscopic state. The mechanisms of water or water vapour absorption are the same [6] although the water absorption process proceeds more intensively.
The absorption of water by textile fabrics as a result of wetting their surface as well as capillary ducts and slots is possible owing to the attractive forces between the molecules of water and fibres.
The hydrophilic properties of textiles are assessed by various measuring methods, the most important of which include [6]:

- testing the surface wettability;
- analysis of water transfer through capillary channels;
- determining moisture absorption;
- water uptake by immersed samples.

It should be also kept in mind that polypropylene belongs to the group of polymers with a high hydrophobicity and in this connection a decrease in the value of this parameter can be of significant importance in some cases of its application.
The hydrophilic properties of solid bodies including textiles depend on their [6]: chemical structure; surface roughness; porosity; presence of foreign molecules on their surface.
The present paper presents the effect of surface modification of polypropylene nonwoven fabric by the layer-by-layer method on its hydrophilic properties.

2 EXPERIMENTAL

2.1 Materials

A polypropylene nonwoven was prepared by melt-blown method (Cenaro – Lodz, Poland) with a surface weight of 27.9 g/m^2 and an average filament diameter of 9.65 μm. Non-wovens were produced using low viscosity polypropylene (lvPP) granulates completely free from additives (HL604FB) produced by Borealis AG, Austria.
Poly(acrylic acid) (PAA) was prepared by polymerization of acrylic acid (AA) in toluene initiated with azobisisobutyronitrile (AIBN). The polymer was rinsed several times with toluene and dried under vacuum. Its weight-average molecular weight (M_w= 145,000 g/mol) was determined by gel chromatography.
Poly(allylamine hydrochloride) (PAH) from Fluka (M_w= 70,000 g/mol) was used without purification.
Polyelectrolyte layers were deposited as described previously [2].
The nonwoven was activated according to [2] by heating in a solution of ammonium persulfate (20 g/dm^3, t=30 min, T=80°C, saturated with nitrogen), thoroughly rinsing with water, and grafting with concentrated acrylic acid (AA) [2] (52 g/dm^3, t=60 min, T=80°C, saturated with nitrogen).
After grafting with acrylic acid the samples were immersed in an aqueous solution of appropriate polyelectrolyte (10^{-2} mol/dm^3). Prior to every such operation samples were rinsed with distilled water [2].

2.2 Determination of acidic groups in the surface layer of fibres

The number of acidic groups was determined with the use of a laboratory pH conductometer/salinometer CPC-502 from ELMETRON, operating in the mode of pH measurement with a combined glass electrode. A weighed portion of fibres (from 0.1 g to 0.35 g) was flooded with 5 ml of 0.01 M NaOH solution and then 75 ml of distilled water was added. The system was titrated by means of 0.01 M HCl solution (during stirring with a magnetic stirrer). The same procedure was used to titrate unmodified fibres. There was prepared a diagram of the dependence of pH on the volume of the acid added and the equilibrium volume of acid, i.e. its volume at pH 7. The number of acidic groups formed due to the modification was calculated from the difference of titration results between the unmodified and modified samples and recalculated per 1 g of fibre.

2.3 Dyeing tests

Samples with different numbers of layers were immersed into 0.001 mol/dm^3 methylene blue solution for 10 min. After immersion in the dye solution the nonwovens with multilayer films were soaked in water for 1 min and then dried with a mild flow of air. All the dyed samples were subjected to measurements of light reemission. Dyed samples were placed in a Spectraflash 300 apparatus (Datacolor International) to measure their light reemission within the range from 400 to 700 nm.

2.4 Measurements of the hydrophilic properties of fibres

Surface wettability was determined by measuring contact angle. A water drop with a volume of 5 μl was applied on a sample previously conditioned (T=26°C, air humidity 29%, t=48 h) and its enlarged image was observed and photographed using a microscope camera (Micro Ocular) and a program for the processing of microscope

photos (Unlead Photo). Contact angle was calculated graphically by means of the Image J program.

Capillarity was examined by applying a coloured drop (0.1 cm^3) of 0.1% potassium dichromate solution on a flat surface of previously conditioned fabric (T=26°C, air humidity 29%, t=48 h). The sample was left for 24 h and then the colored fabric fragments were weighed.

Moisture absorption: The samples to be tested were first conditioned for 48 h under standard conditions (T=24°C, air humidity 29%) and then weighed and placed under conditions of maximum humidity (T=24°C, air humidity 99%) for a period of 48 h, next, the samples were reweighed and the percentage of moisture content was calculated on the basis of the difference between the two weight values.

Water uptake: Prior to testing samples (5 x 5 cm^2) were conditioned in a dry desiccator (T=24°C, air humidity 29%) and then immersed in a water bath 5 cm from water surface, the bottom and walls of the bath container. After 5 minutes of soaking, the samples were left to drain for another 5 minutes. Finally, the samples were weighed and the percentage of absorbed water was calculated per weight unit.

3 RESULTS AND DISSCUSSION

3.1 Deposition of polyelectrolyte layers on the surface of polypropylene nonwoven fabrics

The surface of polypropylene nonwoven was modified with the use of poly(acrylic acid) (PAA) as a negatively charged layer and poly(allylamine hydrochloride) (PAH) as a positively charged layer. The first layer was deposited on the surface of fabric by grafting acrylic acid. The next layers were deposited by the layer-by-layer technique according to [2]. The resultant system is shown in Table 1.

Table 1 Composition of deposited layers

Layer number			
Grafting	Deposition		
1	2	3	4
PAA	PAH	PAA	PAH

The structure of modified samples was confirmed using dyeing tests and volumetric analysis.

Dyeing tests

The deposition of polyelectrolyte layers was confirmed by the method of dyeing test with methylene blue dye. This dye belongs to the group of thiazine dyes and is used to dye the surfaces of acidic character. Therefore one should expect considerable differences in the intensity of colour of the test dyed fabrics before modification and those containing the last layer of poly(acrylic acid) or the external layer of polyamine. Similar analyses of textiles modified by the lbl method are reported in the literature [2, 5, 7].

The dyed samples show visual differences in the intensity of colour: sample 1 and 3 have clearly deeper blue colour than samples 0, 2 and 4.

Not to confine oneself to the evaluation of colour by means of human eye, spectrophotometric measurements of scattered light (S) were also performed. The intensity of reflected colour was measured by means of a spectrophotometer within the range of maximum light reemission for methylene blue (550 – 600 nm).

The relationship between K/S (the coefficient of absorption (K) and scattering (S)) and the coefficient of light reflection (R) has been derived by Kubelka and Munk:

$$\frac{K}{S} = \frac{(1-R)^2}{2R} \qquad (1)$$

The dependence of K/S on wavelength is shown in Figure 1.

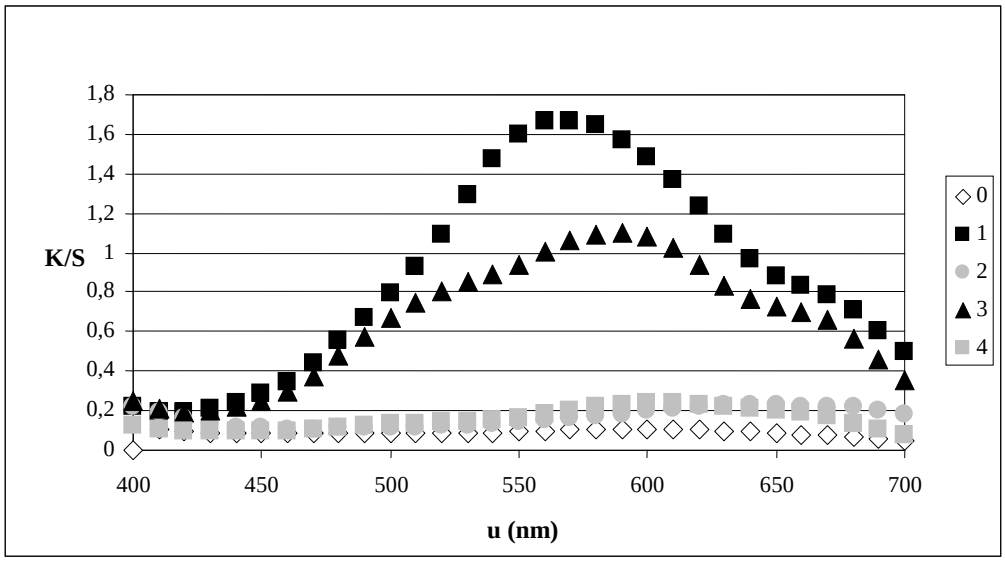

Figure 1 Methylene blue dying tests results

As is seen in Figure 1, the number of acidic groups on the surface with the external PAA layer (samples 1 and 3) is considerably higher than that on the sample with the external PAH layer and on the sample with unmodified surface, which is reflected by the measurements of colour intensity obtained with methylene blue.

The use of colour tests in the work on the modification of textiles is very useful as it allows a quick and simple control and evaluation of the deposition process, giving results that can be easily and quickly visually interpreted.

Volumetric analysis

The volumetric inverse analysis is a very simple technique, requiring no special apparatus. When a relatively large surface of textile fabric is used (in this case, 1 g of sample was used for analysis), it is possible to quantitatively determine the average number of acidic groups that are present in the deposited layers. It is also possible to evaluate the non-uniformity of structure. This technique finds its application in the assessment of changes in surface properties [2, 8, 9].

The determination of the increase in the number of acidic groups was preceded by the analysis of sample 0 (unmodified). The calculated increase in the number of acidic groups is shown in Table 2.

Table 2 Increase in the number of acidic groups on the surface of PP nonwoven after various stages of modification

Sample	Amount of acidic groups [mmol/g]
0	-
1	0.023
2	0.006
3	0.021
4	0.012

The concentration of acidic groups in sample 1 (grafted with acrylic acid) considerably depends on the grafting conditions and is contained within the ranges reported in literature [8, 9]. The lower quantity of carboxylic groups in the sample with the second acidic layer (3) in comparison with the grafted sample, and some quantities in the samples finished with PALL (2 and 4) suggest some accumulating non-uniformity of the surface cover.

3.2 Contact angle measurements

The measurements of contact angle on textile fabrics are not easy to perform due to the complex fabric structure. However in the case of hydrophobic unmodified polypropylene (PP) nonwoven (sample 0) it

is possible to place a water drop on its surface and consequently to measure its contact angle. The contact angle calculated amounts to 142° and the drop disappearance duration is 142 minutes.
On the other hand, in the case of a PP sample grafted with acrylic acid (AA) [1] and after further stages of modification, the drop spreads into the fabric structure and it is impossible to measure neither the contact angle nor the duration of drop disappearance. This is connected with the considerable step-wise increase in the fabric hydrophilicity taking place already after the grafting stage [10].
Significant changes in the values of contact angle have been also observed in textiles with modified surface such as polyester fabric treated with plasma [11], polyamide and polyester fabrics modified with UV radiation [12] or synthetic fabrics treated with corona discharge [13]. A considerable increase in wettability has been found in the case of photo-grafted PP fibres [14].
In order to express the observed increase in hydrophilicity quantitatively, there were carried out measurements of the drop spreading over a surface owing to capillarity forces.

3.3 Capillarity

The phenomenon of capillarity takes place when a liquid is spread on a surface owing to capillaries.
Textiles have no isolated capillaries but there are systems of pores linked together that form irregular capillaries with various diameters. Hence in hydrophilic fabrics, water passes from greater to smaller capillaries. Thus the capillarity plays a very important role in the process of water absorption as it facilitates water transport into areas being beyond the wetting spot [14]. The capillary transfer of a liquid can proceeds in the parallel or rectangular direction to the fabric surface depending on the arrangement of fibres. Depending on the fabric structure, the crossing of capillary lines is also possible. In the case of hydrophobic surfaces, capillary forces fail to spread out water.
Capillarity tests were performed for all the samples. The results obtained are shown in Figure 2.
The liquid capillarity in modified samples is considerably larger than that in the initial sample (0). This increase amounts to several hundred percent for all the samples.

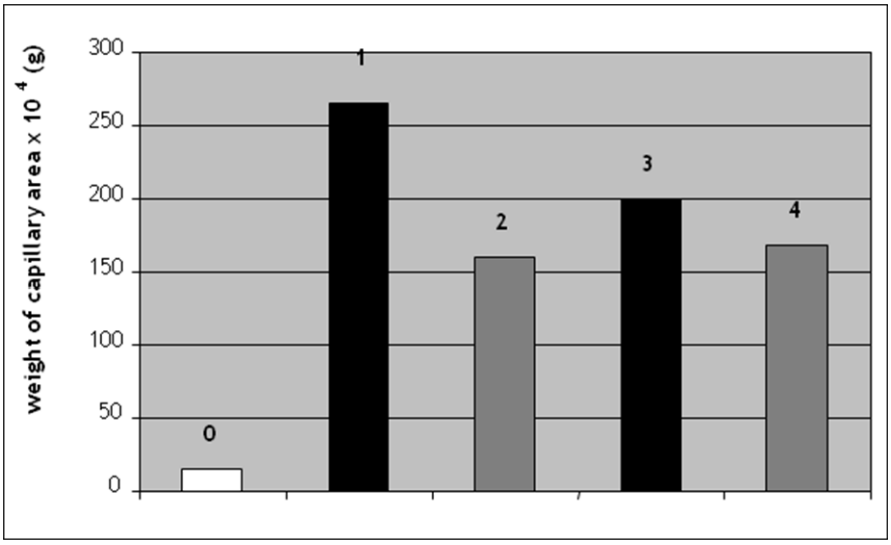

Figure 2 The weight of capillary area for all samples

Literature data have also confirmed that it is possible to control the surface hydrophilicity by an appropriate selection of layers to be deposited [15-16]. Significant changes in capillarity have been found in synthetic textiles modified with plasma [17, 18]. It should be also mentioned that samples with acidic layers are slightly more hydrophilic than those terminated with amine as the carboxyl group is somewhat more hydrophilic than NH_2 group, which is consistent with the observation reported in literature [19]. The theoretical molar values of hydrophilicity (molar water content) determined by van Krevelen are higher by about 7% for carboxyl group than that for amine group (0.35:0.375 mole/mer).

3.4 Moisture absorption

Hygroscopicity or capability of absorbing water vapour and water is a derivative of the hydrophilic properties of textile fabrics.

The tests of moisture absorption by textiles play important part in the assessment of both the performance properties of fabrics and parameters of a possible technical application. The most frequently determined parameter in such tests is the weight of water absorbed by a sample after a specified time of testing.

Figure 3 compares the percentage amounts of water absorbed by the samples after various stages of modification, which were stored for 48 h under conditions of elevated air humidity (99%).

Samples containing polyelectrolyte layers show a moisture absorption that is several times higher than that of unmodified nonwoven. Moreover, samples with the final acidic layer are characterised by a higher hygroscopicity than that of samples terminated with amine, which is consistent with earlier tests of hydrophilicity. A similar relationship after the deposition of polyelectrolyte layers on a modified surface (in this case silicon oxide) has been reported in the literature [20].

3.5 Water uptake

The measurements of water uptake play a great role in the assessment of hydrophilic and hydrophobic finishes. They are often used to test fabrics, for which the measurements of surface wetting fail to give reliable results [11]. In all methods, a conditioned sample is immersed in water under closely specified conditions. After some time, samples are taken out and after removing excess water they are reweighed. The amount of water absorbed by the sample is used to calculate its water uptake.

Figure 4 shows the results of static analyses for samples at various stages of modification. In the samples with deposited nanolayers of polyelectrolytes, one can observe a clear increase in water uptake in relation to that of unmodified sample. However in the measurements of water uptake in comparison with surface wettability, capillarity or hygroscopicity, one can notice that a more important role is played rather by the number of layers than their type. Similar observations have not yet been reported in the literature.

The differences in water uptake between unmodified sample and the samples containing deposited layers are slightly smaller than those in other analyses of hydrophilicity. This is connected with the structure of nonwoven that holds in its material some amount of water during direct contact with it.

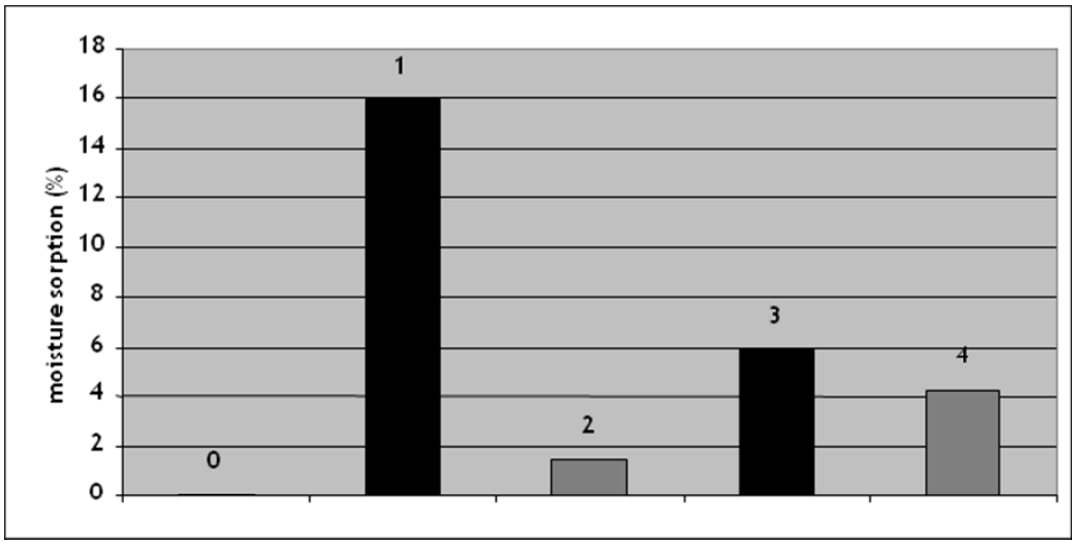

Figure 3 Moisture sorption for all samples

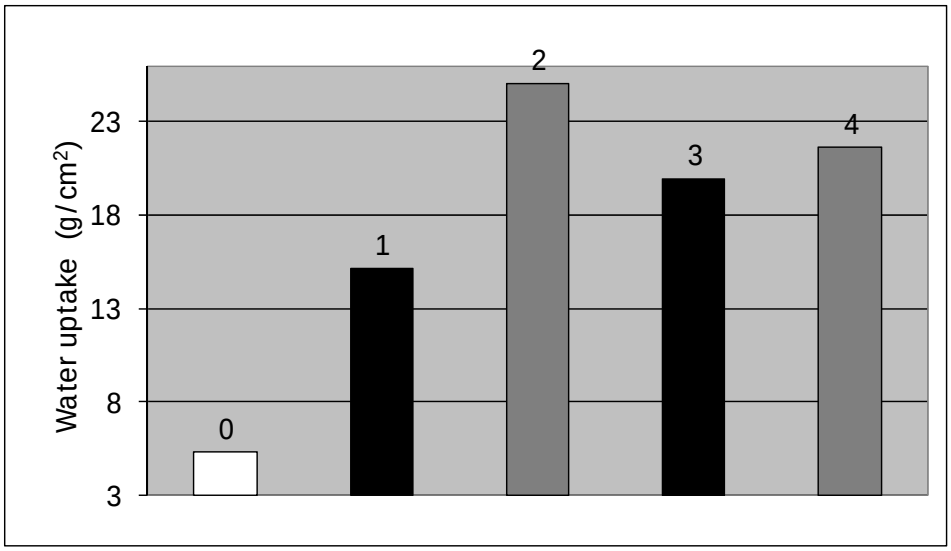

Figure 4 The values of water uptake for all samples

4 CONCLUSIONS

All the above presented methods for the measurement of hydrophilic properties have shown a radical increase in this parameter for samples with deposited layers. Depending on the type of deposited layer and the number of layers, one can control the given parameter at a required level. The modifications of hydrophilicity can considerably extend the potential applications of the modified textiles.

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HYDROFILNÉ VLASTNOSTI POLYPROPYLÉNOVÝCH NETKANÝCH TEXTÍLIÍ PO POLYELEKTROLYTICKOM VRSTVENÍ

The translation of article

Hydrophilic properties of polypropylene nonwovens after polyelectrolyte layers deposition

Príspevok sa zaoberá hydrofilnými vlastnosťami netkaných polypropylénových textílií upravených metódou vrstva na vrstvu. Na prípravu viacerých typov multivrstiev boli použité kyselina polyakrylová a poly(alylamínhydrochlorid). Bolo zistené, že sorpcia vlhkosti, kapilarita, zmáčateľnosť a zádrž vody podstatne vzrástli po nanesení polyelektrolytu.

INFLUENCE OF PARAMETERS OF FABRICS AND ULTRASONIC MACHINE ON PROPERTIES OF ULTRASONIC SEAMING

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Abstract: *The clothing and technical textile industries have recently been using unconventional joining techniques (ultrasonic, thermal, high frequency) to replace classic sewing. This paper seeks to investigate the possibility of ultrasonic welding in production, and the strength of obtained connection. Fabrics were joined using the classic and ultrasonic joining techniques with the following bonding parameters: bonding force, welding speed, geometry of anvil wheels and different content of natural and thermoplastic fibres.*
Key words: *fibres, fabrics, textiles, ultrasonic welding, seam welding*

1 INTRODUCTION

Ultrasonic joining is a method of choice for many applications in the automotive industry, appliance, medical, textile, packaging, toys, and electronic markets, etc. The basic advantages of ultrasonic assembly - fast, strong, clean and reliable seams – that are common to all products. However, each market and products has specialized needs that ultrasonic welding can to meet [1, 2].
The welding (in terms of bonding) of several textiles - or natural-fibre-layers requires the fabrics to consist of a certain amount of thermoplastic material, which is deformable by heat. Ultrasonic roll seam welding machines are replacing traditional sewing machines. Fabrics made from termoplastic fibres are not then longer sewn with a thread, but welded by ultrasound [3].
The use of progressive technologies of processing of fibres and spinning of materials resulted in a substantial expansion of the assortment of synthetic fabrics, which by the ultrasonic welding unite acquire wares from natural fabrics. Taking account of the above-said and the fact that technical textile industry has been begun to successfully replace recently the classic sewing process with more contemporary joining techniques, such as thermal, high frequency and ultrasonic sealing [6]. The aim of this thesis has been to investigate whether it is possible to apply ultrasonic welding for fabric, which includes synthetic and natural fibres and how much it can to meet demands.

2 EXPERIMENT

Concerning the aim and in line with the foreseen investigation plan, fabrics were joined using the classic and ultrasonic joining techniques with the following bonding parameters: bonding force, welding speed and geometry of anvil wheels, which were varied. In addition, fabrics of different composition were used (Table 1). Samples (Figure 1) were prepared under normal conditions as per EN 20139.

For the purposes of this work, samples were joined by:

- The Pfaff 8310 Seamsonic ultrasonic welding machine. Welding speed ranges from 0.6 to 13.6 m/min, and welding pressure ranges from 0 to 800 N. The appearance of the ultrasonically welded seam (Figure 2), i.e. the impression of an engraved pattern, depends on the shape of anvil wheels. Four anvil wheels were used in order to select the best seam (Figure 2).

– The Juki DDL-5530 sewing machine. The seam was made with a lock stitch class 301; needle the Groz-Beckert® N 80/12 type Gebedur and polyester thread Amann 100% PES N120 were used for sewing.

Table 1 Structural properties of fabrics

Reference designation	Fibre content [%]	Weave	Surface density [g/m^2]	Thickness [mm]
A	100 PES	Twill	270	0.50
B	70 PES, 30 Wool	Twill	280	0.55
C	55 PES, 45 Wool	Twill	280	0.68

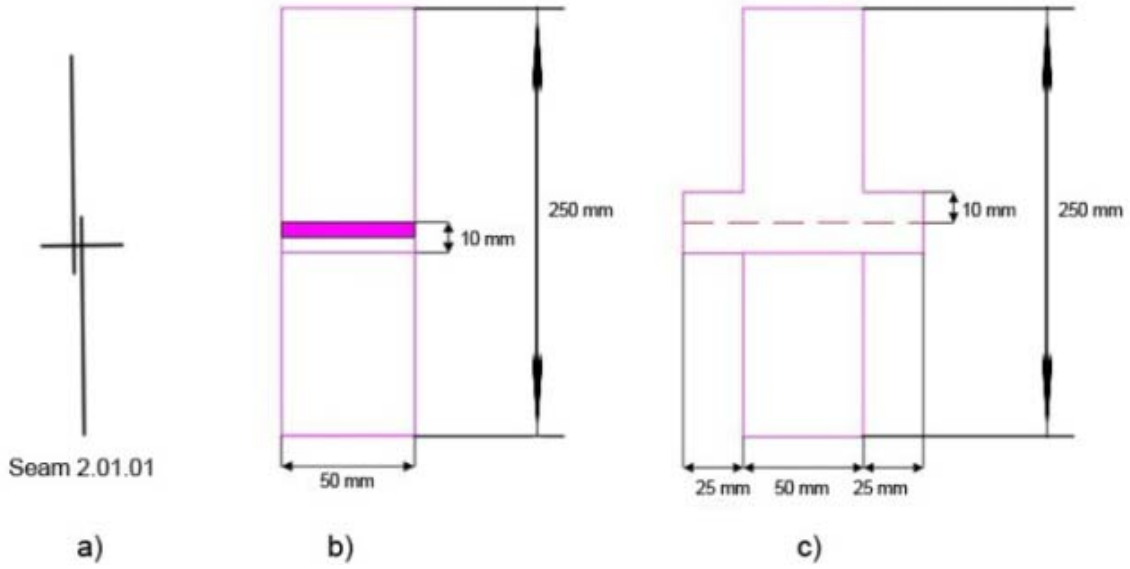


Figure 1 Samples: a) classification seam, b) sample for ultrasonic joining, c) sample for classic thread joining

Ultrasonic joining was realized with the following parameters:
- at bonding force A=50%, speed v_1=0.6 m/min, v_2=1.0 m/min, v_3=1.5 m/min;
- A=70%, v_1=1.5 m/min, v_2=2.0 m/min, v_3=2.5 m/min;
- A=90%, v_1=2.0 m/min, v_2=3.0 m/min, v_3=4.0 m/min.

Classic seam was realized with the following parameters:
Seaming pitch l_1=5 mm, l_2=3 mm, l_3=1 mm. Objective quality evaluation of strength of the bond was made on the tensile-testing machine Labtest 2.5x, where the value of breaking force was determined in accordance with ČSN EN ISO 13935-1.
Size of samples:
working part – 200 mm,
loading speed was 100 mm/s,
initial load – 0.1 N.
The measurement error is ± 1%. The results are shown in Table2 and Figures 3-6.

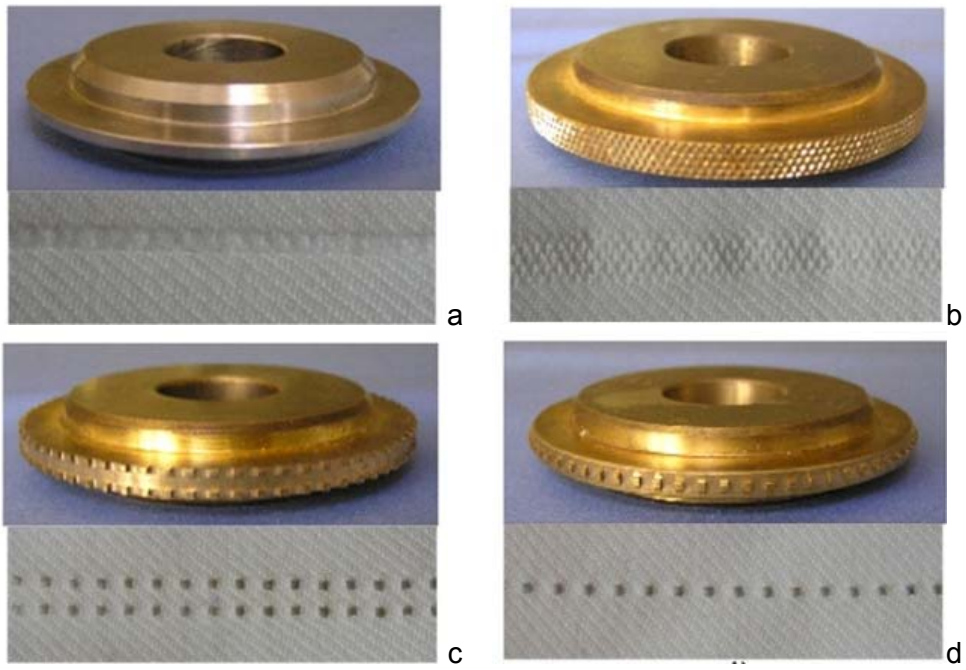


Figure 2 Geometry of the anvil wheels used in ultrasonically welded seam.

Anvil wheel with one-line engraving for ultrasonic welding (Figure 2a), anvil wheel with grate-type engraving for ultrasonic welding (Figure 2b), anvil wheel with two-line point engraving for ultrasonic welding (Figure 2c), anvil wheel with one-line point engraving for ultrasonic welding (Figure 2d).

3 RESULTS AND DISCUSSION

Figures 3-4 show the results of determining resistance of the seams to tensile force.
Figure 3a shows that the tensile strength for fabric A (100% PES) of the ultrasonic bonds obtained by use of the anvil wheel with one-line engraving (Figure 2a) ranges from 76 to 422 N. Where the tensile strength of the bond obtained at the medium amplitude (A=70%) and welding speed (v=1.5 m/min) is the highest, and tensile strength of the bond obtained at the lowest amplitude (A=50%) and the highest speed (v=1.5 m/min) is the lowest.

Table 2 Resistance of the classic seam to breaking force (F_B [N])

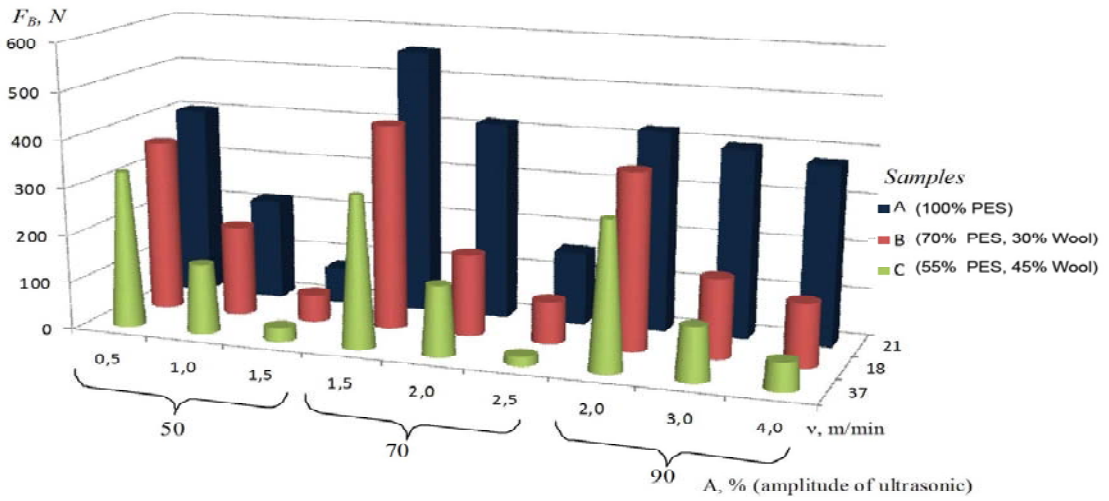
Seaming pitch [mm]	5	3	1
A	57	169	429
B	64	181	451
C	52	178	433

In samples with wool, the tensile strength decreases with the increasing content of natural fibres from 1.1 to 2.4 times less for sample B, and from 1.2 to 4.1 times less for sample C.
When using other types of anvil wheel, analogical changes were observed:

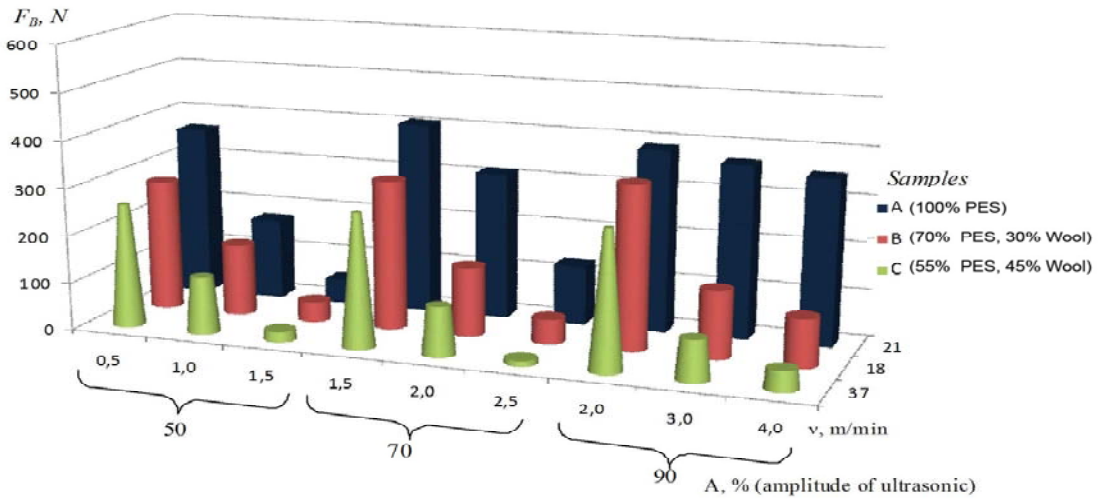
- the smallest values of breaking force at minimum and middle bonding force and high speed;
- the highest values of breaking force at minimum speed;
- with increase of wool fibres the breaking force decreases from 1.1 to 7.0 times.

Breaking force changes for different types of anvil wheel. The maximal and minimal values of breaking force were obtained for the sample welding using anvil wheel with one-line point engraving (Figure 2a) and anvil

wheel with point engraving (Figure 2d) (possibly because of diminishing of the working area).
In that way values of the breaking force are lower 1.1-1.8 times when using the anvil wheel with the grate-type engraving (Figure 3b), 1.3-3.4 times - anvil wheel with two-line point engraving (Figure 3c) and 2.1-5.1 times - anvil wheel with one-line point engraving (Figure 3d).



a) Anvil wheel with one-line engraving for ultrasonic welding



b) Anvil wheel with grate-type engraving for ultrasonic welding

Figure 3 Dependence of breaking force on bonding force and welding speed

The influence of welding area on the values of breaking force (Figure 4) and welding heat on the welding speed and welding area (Figure 6) was made. For determination of the welding heat was used a thermocamera Fluke Ti25 (Figure 5).
As show in the results the welding area has great influence. The relation between breaking force and welding area was

constructed on their basis (Figure 4). Dependence has high correlation coefficient ($R^2 > 0.9$), only in three cases it is slightly lower ($R^2 = 0.87 – 0.88$). This relation enables to forecast welded strength at the use of anvil wheel with other geometry (the Pfaff8310 Seamsonic ultrasonic welding machine has more than 20 forms of anvil wheel).

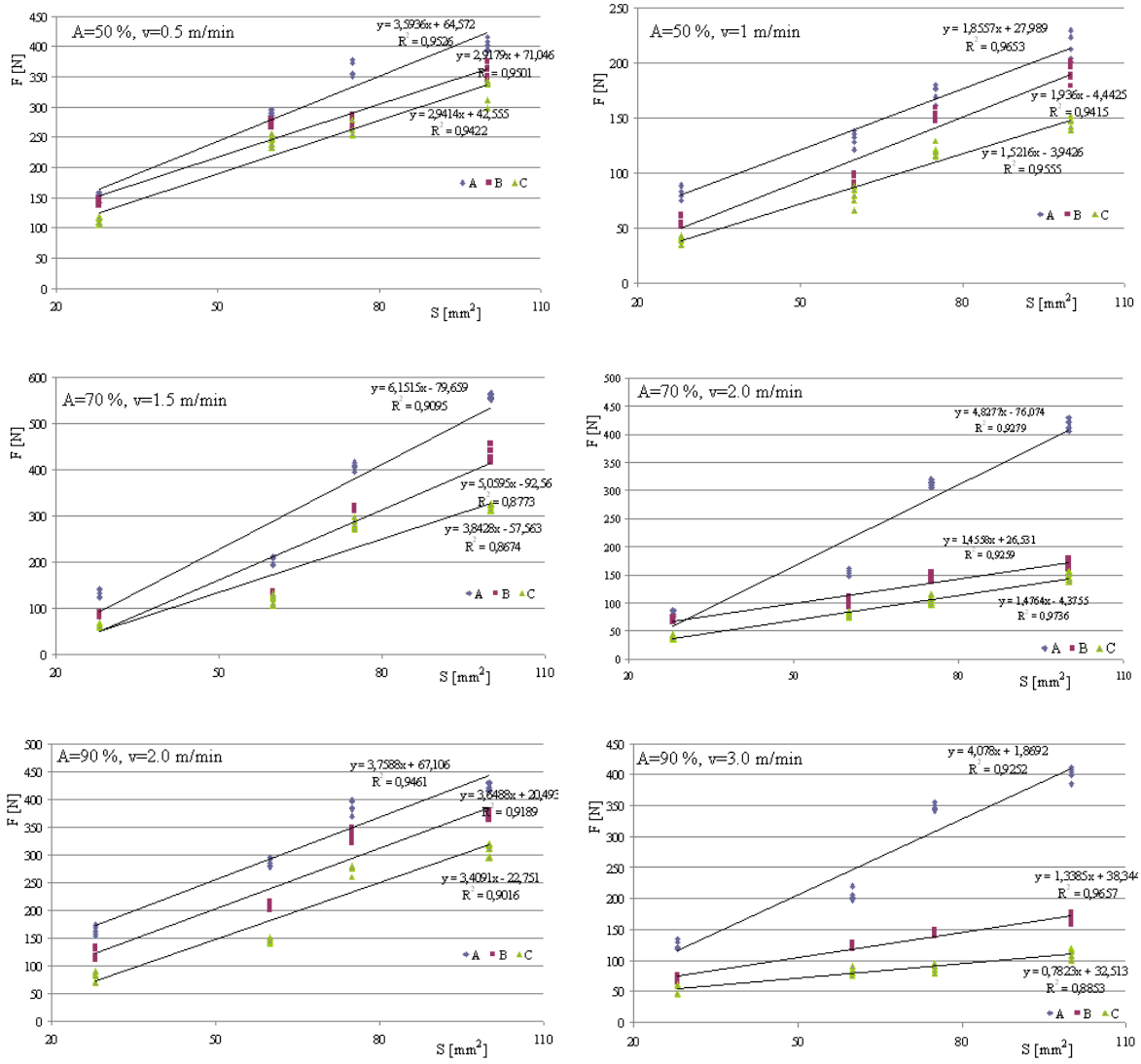


Figure 4 Breaking force-welding area relation
A (100% PES), B (70% PES, 30% Wool) C (55% PES, 45% Wool)

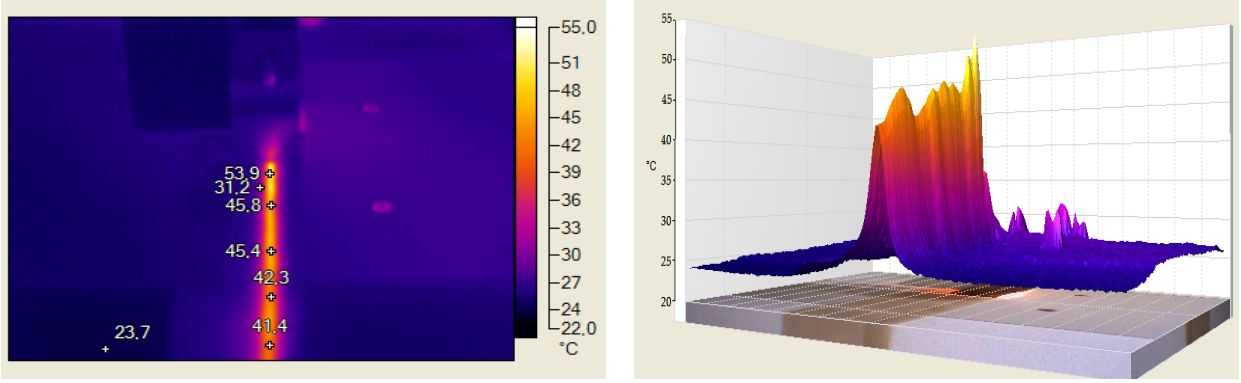


Figure 5 Welding heat of sample A (100% PES), anvil wheel with one-line point engraving (welding area 28 mm^2)

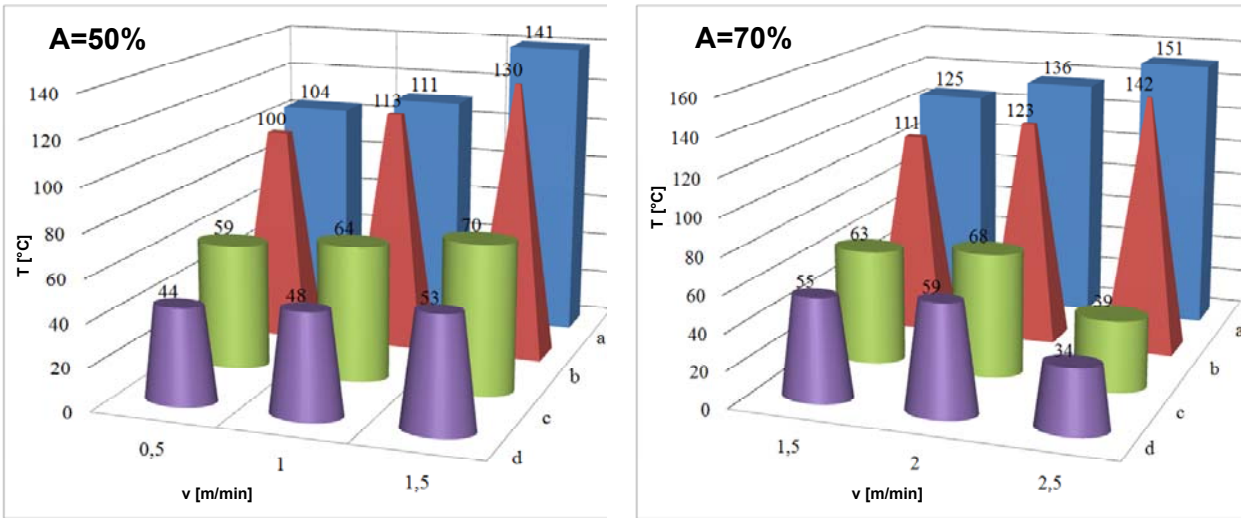


Figure 6 Dependence of welding heat on the welding speed and welding area:

a) anvil wheel with one-line engraving (welding area 100 mm^2);
b) anvil wheel with grate-type engraving (welding area 75 mm^2);
c) anvil wheel with two-line point engraving (welding area 60 mm^2);
d) anvil wheel with one-line point

From equation (1) [7] it is possible to get basic conformities to the law, showing dependence of welding time t on other parameters (amplitude and frequency of ultrasonic vibrations, geometrical sizes, such as an area and thickness of the weld, acoustic properties of materials, density, speed of sound, taking into account a reflection and absorption of ultrasonic energy etc).

$$t = \frac{\rho_1 \Delta T V_1 \int_{T^n}^{T^{min}} C dT + \lambda \rho_1 V_2 + Q}{2\pi^2 f^2 A_0^2 S \rho_0 c_0 (1-\eta_1)(1-e^{-4\alpha w} + \eta_2 e^{-4\alpha w} - \eta_2 e^{-6\alpha w})} \quad (1)$$

ρ_0, ρ_1 – density of operating tool and thermoplastic materials, kg/m^3;
ΔT – difference between room temperature and fusion temperature, K;
C – heat capacity J/kg·K;
V_1,V_2 – volume of welding area and weld, m3;
λ – specific heat of fusion materials, J/kg;
Q – losses of heat from a weld zone, J;
f – frequency, Hz;
A_0 – amplitude, m;
c_0 – velocity of sound in operating tool, m/s;

η_1 – reflection coefficient at the border operating tool and welding materials;
η_2 – reflection coefficient at the border welding materials and anvil;
a – attenuation coefficient of amplitude, 1/m;
x – thickness of thermoplastic materials, m.

Findings (Figure 6) are confirmed by this equation. Consequently, weld strength with increase of temperature must be increased. In practice, (Figure 3) weld strength diminishes at the increase of welding speed. Therefore, welding time (welding speed) has fundamental influence on ultrasonic welding.
According to the results shown in Figure 3 and Figure 4, it may be concluded that ultrasonic welding, together with the selection of optimal parameters (speed, bonding force and geometry of anvil wheels), can successfully replace classic sewing in some cases (for example airtight and airtight seams, etc.). Namely, the strength of an ultrasonic bond is, as a rule, higher than the strength of classic seam.

4 CONCLUSION

This paper is devoted to strength of ultrasonic welding for textile materials with different content of PES and wool fibres. Ultrasonic welding is effective for fabrics containing less than 45% of wool fibres.
Wool fibres influence the strength of ultrasonic welding. The values of breaking force decrease 1.1-4.2 times (depending on the type of anvil wheels used) and these facts must be taken into account when planning production.
The values of breaking force for 100% PES are for ultrasonic welding (A=70%, v=1.5 m/min) 2.5 times higher than for the classic sewing (seaming pitch 2.5-3.0 mm).
The values of breaking force of a welding seam are changing according to the different geometries of anvil wheels (welding area), correlation coefficient is high (R^2=0.87-0.97).
At identical speed at Pfaff 8310 (ultrasonic welding machine) (A=90%, v=3 m/min), using anvil wheel (with one-line anvil, grate-type, two-line point engraving), values of breaking force for 100% PES are 1.1-2.2 times higher than for Juki DDL-5530 (classic sewing machine) (seaming pitch l=3mm).

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VPLYV PARAMETROV TKANÍN A ULTRAZVUKOVÉHO PRÍSTROJA NA VLASTNOSTI ULTRAZVUKOVÉHO SPÁJANIA

The translation of article

Influence of parameters of fabrics and ultrasonic machine on properties of ultrasonic seaming

V oděvnictví a ve výrobě technické konfekce nekonvenční spojování (ultrazvukem, vysokofrekvenčním svařováním atd.) v poslední době nahrazuje klasické spojování šitím. Předložený příspěvek předkládá výsledky výzkumných prací týkajících se ultrazvukového svařování plošných textilií a pevnosti vytvořených spojů. Je porovnávána pevnost spoje plošných textilií vytvořených klasickým šitím a ultrazvukovým svařováním v závislosti na obsahu termoplastických vláken, rychlosti svařování, druhu tvarovacích koleček svářečky, přítlaku a výkonu ultrazvukového přístroje.

STRATEGIES FOR WATER RECYCLING IMPLEMENTATION IN SLOVENE TEXTILE COMPANIES

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Abstract: *This paper presents proposed solutions for water reuse implementation in two Slovene textile finishing companies.*
As a first step a very complete database was obtained with the collection and characterization of all relevant water related textile production processes. On the one hand, data concerning water use, chemicals and energy were collected for all relevant production processes. On the other hand, all relevant batch discharges from each process were analyzed by measuring relevant ecological parameters. Afterwards textile effluents were classified in high and low concentrated, in view of their separate treatments and further reuse possibilities. The distinction between low and high concentrated effluents was based on effluents potential treatability by membrane and AOP technologies and their reusability in textile processes. As final step laboratory scale dyeing with recycled water and process water was realized with the aim of colour difference determination between normal process water and recycled water.
Keywords: *textile finishing industry, water reuse, water scarcity*

1 INTRODUCTION

Sustainable water use becomes one of the most important issue in European water policy. Textile finishing industry is very water intensive. Wastewater is by far the largest waste stream in the textile industry. Scouring, dyeing, printing and finishing processes generate the majority of wastewater, as they require many rinsing sequences after each step.
For development of strategies for water treatment and reuse, complete characterization of water related textile process effluent streams is needed. When the characteristics of the separate streams/discharges are known, it can be decided which streams/discharges can be combined, to optimize treatability and suggest reuse options. Normally in textile finishing companies do not use any water reuse, while fresh high quality water is needed in all the production processes. The stringent environmental regulations and water scarcity in some European regions force the textile industry to examine the potential for reusing the water from the textile wastewater streams. The choice of the treatment technology depends on the nature of the wastewater and also on the amount of annually used fresh water [1, 2].
A general quality standard for textile water to be reused it is quite difficult to define, because of the different requirements of each textile material and of the textile process applied and because of the different quality required for the final fabric. Parameters need to be considered for reuse was used as initial guidelines as suggested by different authors [3, 4].

In the present study after the complete chemical characterization, criteria for the effluent separation in so called low concentrated and high concentrated effluents, based on their treatability and further reusability were defined. Afterwards, simple reuse scenarios were proposed.
In these scenarios wastewater treatment technologies proposed are different combinations of membrane treatment by ultrafiltration/nanofiltration and advanced oxidation by UV/H_2O_2 for low concentrated waste streams. Treated samples were further used in so called ″reusability″ experiments where laboratory dyeing of cotton according to company dyeing procedures were realized. Characteristics of dyed cotton material were compared to the cotton material dyed with normal process water.

2 RESULTS AND DISCUSSION

All individual discharges connected to textile processes that are relevant on yearly basis were collected and characterized by physical-chemical parameters. Normally in textile SMEs machinery are used to carry out different production processes. For this reason the diversity of waste discharges characteristics could vary significantly.
The significant fluctuation of pollution level of waste discharges from different textile production processes is presented in Tables 1 and 2.
Particularly streams were very polluted expressing in high conductivity, absorbance, COD and total suspended solids. Other streams are not so concentrated and after proper treatment the quality of recycled water could be good enough to be reused. So called ″low polluted streams″ from different textile processes (dyeing, washing, rinsing..) were collected separately and treated by membrane techniques and AOP separately or with different combinations of both techniques. The more concentrated effluents and the concentrates produced by the membrane technologies should be treated with different technologies appropriate for so called ″high concentrated″ streams.

By proposed treatment procedures for low concentrated streams we have tried to achieve the following values of parameters need to be considered for water to be reused according to literature data:

- **pH**: Almost all the authors agree on a pH required in the range of 6.5-8.0.
- **Conductivity**: Most of the authors suggest maximum values in the range 1-2 mS/cm.
- **Suspended Solids**: The authors suggest maximum values in the range 5-50 mg/L.
- **Turbidity**: Only one author proposes a maximum value of 1.0 NTU.
- **Total COD**: Maximum values for reuse range between 10 and 160 mg/L.
- **Colour**: Most authors recommend the water should be colorless (roughly corresponding to an absorbance at each wavelength <0.01 cm^{-1}).
- **Metals**: According to what is suggested by most authors, to dyestuff producers and textile finishing company recommendations the following values are proposed: Iron 0.1 mg/L, Manganese 0.05 mg/L, Copper 0.05 mg/L.

According to the conclusions drawn from the analysis of the existing water and wastewater network and from the effluents characterization, simplified reuse network scenarios were designed. Scenarios are based on machinery separation and on effluents separation based on continuous monitoring of the effluents characteristics. In these scenarios wastewater treatment technologies evaluated are different combination of coagulation, UF, NF, AOP (UV/H_2O_2), MBR and evapoconcentration. To evaluate the effectiveness of proposed reuse scenarios simple laboratory scale dyeing experiments were performed using treated water with proposed treatment technologies.
Identical pieces of cotton fabric were put in dyeing vessels together with the samples of dye bath. Vessels containing fabric and dye bath were installed in the laboratory dyeing machinery that simulates the real condition of full scale dyeing. Dyed fabrics were washed

and dried and in the end dyed material was evaluated by colour matching.
In general laboratory dyeing experiments using recycle water gave promising results in comparison to dyeing with normal process water.

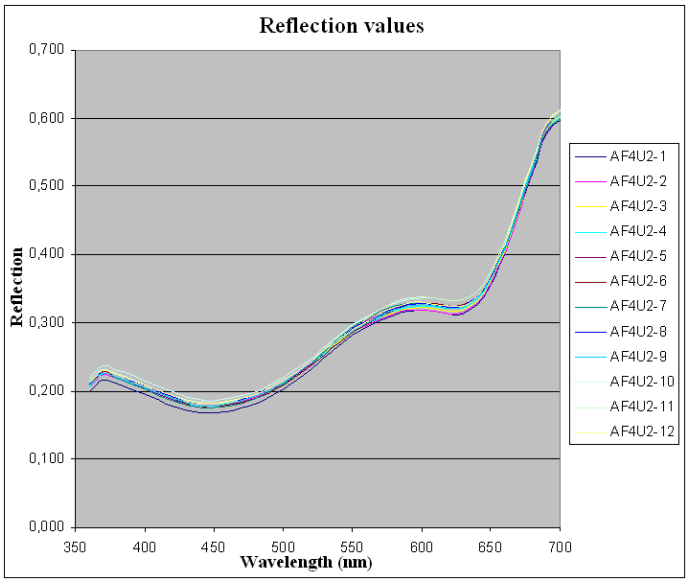
As an example reflection curves of dyed material with recycled water obtained after different combinations of proposed treatment technologies are presented in Figure 1.

Table 1 Pollution level of different textile discharges from individual processes

Sample	pH	Conductivity [μS cm^{-1}]	Turbidity [NTU]	COD [g L^{-1}]	TSS [g L^{-1}]	Absorbance		
						436	525	620
Dyeing yarn, reactive dyes, light	10.8	46900	9	792	94	0.49	1.91	0.32
Dyeing yarn, reactive dyes, dark	10.2	71900	0	3850	154	15.66	18.75	2.51
Dyeing fabric, foulard, reactive dyes, dark	13	69400	3	31960	1852	124.5	272.4	450.2
Fabric washing and bleaching	12.7	24100	200	32409	2850	0.89	0.56	0.39
Fabric bleaching, foulard	12.9	115200	200	61900	7629	2.85	2.54	2.37

Table 2 Ion content of different textile discharges from individual processes

Sample	Cu^{2+}	Mn^{2+}	Fe	Na^{+}	Ca^{2+}	Cl^{-}	SO_4^{2-}
Dyeing yarn, reactive dyes, light	0.602	0	0.026	12400	9.094	>3000	400-800
Dyeing yarn, reactive dyes, dark	5.75	0.0001	0.053	15000	7.25	-	400-800
Dyeing fabric, foulard, reactive dyes, dark	930.9	0	0.823	12000	0	-	-
Fabric washing and bleaching	0.155	0.067	0.639	3700	0	500	>1600
Fabric bleaching, foulard	0.277	0.357	0.303	19400	7.936	-	>1600



LEGEND:
1...discharge after washing treated with COAG. + UF (holow fibre)
2...discharge after washing treated with UF (holow fibre) + NF
3...discharge after dyeing treated with UF (holow fibre) + NF
4...discharge after dyeing treated with COAG. + UF (holow fibre)
5...discharge after washing treated with UF (spiral wounded) + NF
6...discharge after dyeing treated with UF (spiral wounded) + NF
7...discharge after printing mis treated with COAG. + UF (holow fibre)
8...discharge after washing treated with UF (holow fibre) + AOP
9...discharge after washing treated with AOP (1600 W, 8,3 mL/L H_2O_2, 30 min)
10...discharge after washing treated with AOP (1600 W, 4,5 mL/L H_2O_2, 30 min)
11...discharge after washing treated with AOP (1600 W, 0,7 mL/L H_2O_2, 30 min)
12...dyeing with process water

Figure 1 Spectrophotometric verification of dyed cotton fabrics with recycled (samples from 1-11) and process water (sample 12)

3 CONCLUSIONS

Above described methodology could be carried out in all SMEs interested in wastewater reuse in the textile sector and in other industrial sectors characterized by a similar (weekly, monthly and yearly) variation of effluents discharges by production machinery. Separation and segregation of waste water for treatment and re-use differs company by company and depends on different factors. Sometimes separation on machinery level is possible, in other companies it will only be based on the concentration of certain parameters. Criteria have to be developed for each case separately to decide on the best way of separation and segregation.
Recycling experiments in textile finishing companies, using treated water for the production purposes should be obligatory part of proposed treatment technologies testings to assure practical applicability of reuse treatment concepts.

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STRATÉGIE ZAVEDENIA RECYKLÁCIE VODY V SLOVINSKÝCH TEXTILNÝCH FIRMÁCH

The translation of article
Strategies for water recycling implementation in Slovene textile companies

Príspevok navrhuje riešenie pre zavedenie recyklácie vody v dvoch Slovinských textilných závodoch. Prvým krokom bolo vytvorenie kompletnej databázy získanej zhromaždením a charakterizovaním zodpovedajúcich textilných výrobných procesov zahŕňajúcich vodu. Na jednej strane boli zhromaždené údaje týkajúce sa použitia vody, chemikálií a energie pre všetky príslušné výrobné procesy. Na druhej strane, všetky príslušné konečné kúpele zo všetkých procesov boli analyzované meraním ekologických parametrov. Potom boli všetky odpadové vody klasifikované ako vysoko a nízko koncentrované z hľadiska ich oddeleného spracovania a ďalšieho možného znovupoužitia. Rozdiel medzi nízko a vysoko koncentrovanými odpadovými vodami bol posúdený na základe ich možného spracovania membránami a AOP technológiami a ich opätovného použitia v textilných procesoch. Posledným krokom bolo použitie recyklovanej vody pri farbení a vodný proces bol realizovaný s cieľom zistiť farebné rozdiely pri použití „čistej“ a recyklovanej vody.

Informácia o tretej medzinárodnej konferencii o materiáloch TEXCO' 2010

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Dátum konania: 1-3. september 2010

V dňoch 2-3.9.2010 sa uskutočnila na Slovensku v Ružomberku už tretia medzinárodná konferencia o materiáloch. Na konferencii sa stretli odborníci zo Slovenskej republiky, Českej republiky a USA. V celkovej ponuke bolo 27 prednášok. V rámci konferencie boli prostredníctvom módnej prehliadky prezentované aj módne trendy v textilnom návrhárstve, ktoré vhodne dopĺňali odborné prednášky. Hlavné konferenčné témy boli zamerané na:

- Novinky z oblasti textilného výskumu
- Skúšanie kvality textilných materiálov
- Textilný a odevný dizajn

V prvej z plenárnych prednášok bola hodnotená súčasná situácia v textilnom a odevnom priemysle i nový pohľad na trendy v textilnom dizajne v európskom textilnom priestore. Bolo zdôraznené, že súčasný dizajnér je nielen tvorcom inovácie vo vzťahu k sezónnej módnej ponuke, ale zároveň často dáva podnety aj k novým technickým a technologickým riešeniam, prípadne sa podieľa na ich výbere a zavádzaní do výrobnej praxe. Dizajn textílie je celkový vzhľad, vrátane konštrukcie textílie a dezén je iba kresba na povrchu textílie.

Bolo definovaných 5 oblastí textilného dizajnu:

1. Textilné dezénovanie
2. Odevný dizajn
3. Textilná galantéria
4. Priemyselný dizajn v textile
5. Bytové textílie

V súčasnej dobe sa zdôrazňuje mimoriadna úloha výrobcov v oblasti inovácii, kvality, technických možností a tiež spolupráca v európskom hospodárskom priestore v oblasti odievania, bytových textílií a globalizácie.

V druhej plenárnej prednáške sa hodnotila situácia v súvislosti s kovovými vláknami. Tretia plenárna prednáška bola orientovaná na bio-vlákna a pojednávala o novinkách v tejto oblasti, o trendoch ako aj otázkach ich ďalšieho využitia.

Prednášky rozdelené do 5 blokov boli zamerané na materiály v prevažnej miere textilné, ale aj na optické vlákna a integrované textílie v medicíne. Prednášky o inteligentných textíliách mali na konferencii svoje zastúpenie v súvislosti s novými možnosťami v zdravotných vedách. Boli prezentované inovácie v oblasti technických textílií aj so zameraním na textílie pre automobilový priemysel. Veľká pozornosť sa na konferencii venovala elastickým vláknam a rôznym technológiám, akými sa dosahuje efekt.

Už tradične sa na konferencii v Ružomberku venuje značná pozornosť športovým odevom. Z prednášok vyplýva, že asi 60% celkovej energie spotrebuje ľudský organizmus pre svoju klimatizáciu. Pri športových odevoch prevláda trend konštruovať „zmesový" materiál na jednotlivé partie tela, aby sa zachovala tepelná rovnováha. Výrobcovia uprednostňujú hlavne PP vlákna a ich aplikáciu v termo prádle.

Špeciálne zastúpenie v tejto oblasti má vlákno Coolmax so svojimi vynikajúcimi transportnými vlastnosťami.
Naši dizajnéri prezentovali nové odevy s využitím recyklovaných textílií, čo na jednej strane umožňuje zvyšovať komfort pri nosení, ale na strane druhej je cena odevu primeraná súčasnému stavu ekonomiky SR.
Firma Áčko prezentovala lyocellové vlákno TENCEL pre bytové textílie (napr. v posteľnej bielizni), najmä pre alergikov, ktorí majú citlivú pokožku v kontakte s inými textíliami.
Nové odevy odskúšané na komfort pri nosení sa označujú značkou kvality „Komfort nosenia“, ktorá dáva spotrebiteľom istotu pri rozhodovaní sa pri kúpe. Komfort je komplexná funkcia, zahŕňajúca mnohé vlastnosti textílie. Komfort je merateľný na základe moderných skúšobných postupov, čo je prínosom vedy v posledných rokoch.
V oblasti pracovno-odevných materiálov sa využívajú nové textílie so špeciálnymi vlastnosťami a modelujú sa nové textilné konštrukcie, ktoré zabezpečujú ochranu v náročných až extrémnych pracovných podmienkach. Od pracovných odevov sa vyžaduje vysoký termo-fyziologický komfort. Špeciálne textilné materiály sa vyrábajú cestou nanotechnológií a funkcionalizáciou povrchov vlákien a textílií. Využívajú sa nové postupy, ako sú plazmatická úprava povrchov a iné nanotechnológie, alebo ich kombinácie.